Letters to the Editor

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EQUIVALENT PRESSURE CONCEPT IN CROSSED ELECTRIC AND MAGNETIC FIELD IN ELECTRODELESS DISCHARGE

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(Received December 29, 1960)

Wehrli (1922) calculated the effect of a magnetic field on the breakdown condition of a gas by assuming that λ, the mean free path of the electron, is constant for all the electrons and under the action of the magnetic field the electrons will describe a cycloidal path and the mean free path λ will change to λ' such that

(1)

Where H is the magnetic field in Gauss, e and m are the charge and mass of the electron and E is the breakdown voltage per centimetre length of the discharge tube. Hence the effect of magnetic field is equivalent to an increase of pressure P to P_e such that

$$P_e = \frac{P}{\left[1-\frac{eH^2\lambda}{8Em}\right]} \quad \ldots \quad (2)$$

Blevin and Haydon (1958) arrived at a new expression for equivalent pressure by calculating the electron mass energy and drift velocity in a magnetic field and P_e in their case is given by

$$P_e = P\sqrt{1+\frac{CH^2}{P^2}} \quad (3)$$

where $$C = \left(\frac{e}{m}\cdot\frac{L}{u}\right)^2$$

L is the mean free path of the electron in the gas at a pressure of 1 m.m. and u is the velocity of the electron. It can be seen from equation (3) that

$$P_e = P\sqrt{1+\frac{e^2}{m^2}\cdot\frac{L^2}{u^2}\cdot\frac{H^2}{P^2}}$$

and if it can assumed that $\frac{1}{2}mu^2 = eEd$ where d is the length of the discharge tube then

$$\frac{P_e}{P}=\sqrt{1+\frac{1}{2}\cdot\frac{e}{m}\cdot\frac{L^2H^2}{P^2Ed}} \quad \text{(Blevin and Haydon's formula)}$$

and from Eqn. (2) ... (4)

$$\frac{P_e}{P} = \frac{1}{\left[\frac{eH^2L}{8PEm}\right]} \quad \text{(Wehrli's formula)}$$

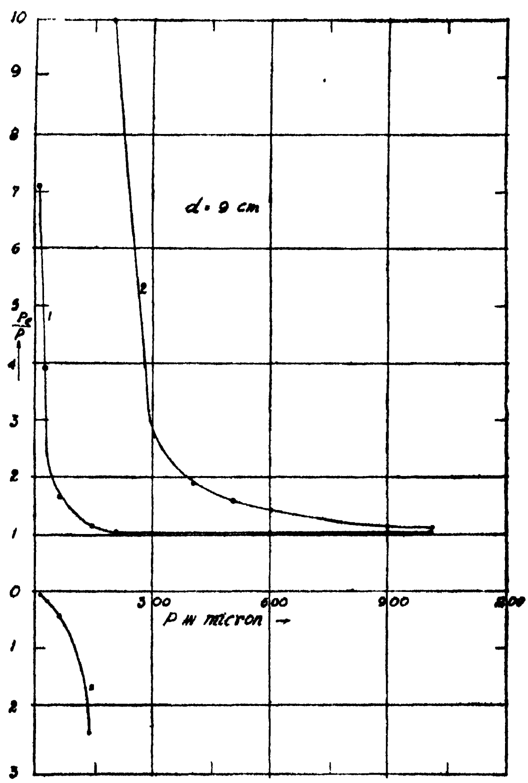

Fig. 1

We have recently measured the breakdown potential in air in crossed electric and magnetic field within the pressure range 1×10^{-3} to 1 mm of Hg, the discharge being excited by means of a 10 KV transformer. The magnetic field has been varied from 50 Gauss to 2000 Gauss and three discharge tubes of length

9 cm, 22·5 cm. and 26·5 cm. have been used. From the measured breakdown potential data, the values of P_e/P have been calculated using both the expressions in Eqn. (4) where the magnetic field has been taken as 100 Gauss and in Figs. (1) and (2), P_e/P has been plotted against the corresponding pressure. From the curves it appears that the relative change of pressure as obtained from Blevin and Haydon's formula is large when the pressure is very small, that is below 60μ of Hg. and then drops suddenly and becomes insignificant above 200μ. On the other hand, Wehrli's formula predicts negative values of equivalent pressure at low pressure which is anomalous. At about 120μ of Hg, P_e/P becomes very large in the case of Wehrli's formula and then drops suddenly and both the curves become asymptotic to the straight line $P_e/P = 1$ at higher pressures. Values of P_e/P calculated for higher magnetic fields also give similar nature of the curve. If calculations for the equivalent pressure be made using Wehrli's formula for

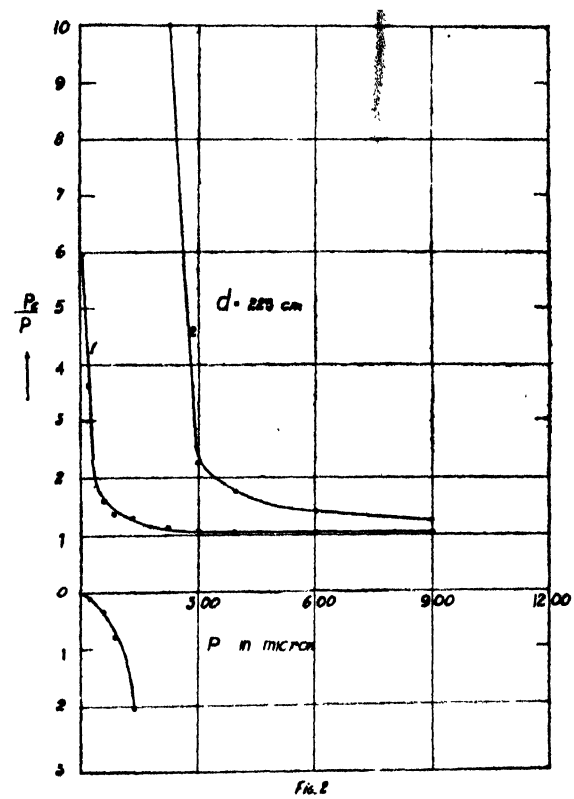

Fig. 2

small values of magnetic field of the order of 15 to 30 Gauss then it predicts positive values of P_e at low pressure. Thus at low pressure, Wehrli's formula becomes valid only if the magnetic field is small. It can be seen from Fig. 1, that both the curves almost provide the same value of P_e/P above 900μ of Hg.

and above 200μ the change of P_e/P is insignificant. But in our experiment it has been noted that the effect of magnetic field on breakdown potential is dominant at higher pressure also. Thus it can be concluded that both the above expressions for P_e are of limited applicability and the concept of equivalent pressure alone cannot explain all the observed results. So far the variation of γ, Townsend's second coefficient in a magnetic field, has been neglected, but we have recently deduced an expression for variation of γ with (E/P) (Sen and Ghosh 1961) and it is hoped that the incorporation of variation of γ with H along with equivalent pressure concept will explain the observed changes better.

ACKNOWLEDGMENT

The present work forms of a programme on scheme on "Electrical discharge through gases and vapours and its investigation by microwave probe and optical method" and the authors are indebted to Council of Scientific and Industrial Research for financing the project. One of the authors (A.K.G.) is grateful for the award of a junior scholarship.

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